Maine Agricultural Experiment Station

BULLETIN No. 141. MARCH, 1907.

POTATO SCAB.

This bulletin contains an account of the causes of potato scab; how soil may be infected, and how infection may be prevented.

Requests for bulletins should be addressed to the
AGRICULTURAL EXPERIMENT STATION,
Orono, Maine.

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BULLETIN No. 141.

THE PREVENTION OF POTATO SCAB.

W. J. Morse.

From the evidence at hand it appears that the amount of potato scab in certain portions of Maine is rapidly increasing. Many bushels of otherwise excellent potatoes are now annually sent to the starch factory, thus materially reducing the profit of the grower. This rapid increase of scab is very evident in Aroostook county. Never has the Station received so many complaints from growers with regard to losses from this cause as was the case last season. An explanation of this condition of affairs is not hard to find. Two years ago on account of the scarcity and consequent high price of seed many farmers planted the scabby tubers which were unfit for market. Very frequently experienced growers are met who advocate this practice, claiming from mistaken observation that there is no danger from the use of scabby seed, thus assisting indirectly in the propagation and spread of the disease. This indicates that the nature of the disease and the importance of planting clean, disinfected seed to insure a clean crop and to guard against infection of the soil is not realized by many growers.

In view of the fact there are still large areas which are free from scab or which are but slightly infected, and each year a considerable amount of previously uncultivated soil is added to the potato growing acreage of the state, it is highly important that ample precautions be taken to prevent the introduction of scab germs into this clean soil.

PURPOSE OF THIS BULLETIN.

The object of this bulletin is to warn growers of the gravity of the situation, to point out the material and lasting injury which will surely result to the potato industry unless proper

attention is given to the control of this disease, and to describe the methods by which it may be held in check.

The writer has drawn largely upon the publications of other stations and upon the results of his own experience and investigations most of which have already been published.*

In this connection it should be stated that this is by no means the first time that this Station has called the attention of the Maine growers to this disease. An examination of the files shows that 19 years ago the botanist made quite an extended study of the subject in an effort to determine the cause of the malady and two years later he reported that its parasitic nature had been demonstrated elsewhere. Additional reports were made in 1893 and 1894. In the spring of 1905 a circular letter was sent to the newspapers circulating in Aroostook county and in 1906 a special bulletin was sent to all of the newspapers of the State briefly stating the essential facts as to the nature and cause of the disease, the ways in which the soil becomes infected, the conditions favoring development and spread, and a summary of the best methods of its control. Especial attention was called to the danger of using infected seed and to the lack of appreciation on the part of the growers of the importance of the disease.

PLANTS AFFECTED BY SCAB.

The roughened, scabby, pitted surface of potato tubers affected with scab is too well known to require description. It is probable that no other potato disease has a wider distribution. In addition to being disseminated throughout this country it occurs in various parts of Europe and different writers have reported it in South Africa and New Zealand as well. It probably occurs wherever the potato is grown.

In addition to the potato, beets, mangels, turnips and rutabagas are quite susceptible to the disease. It has also been found on cabbage and carrot roots and possibly may develop in a slight degree on radish, salsify and parsnips. It is possible that the fungus has still other hosts, for as shown later it is able to persist in the soil for some years without the presence of any of the above mentioned crops.

* Vt. Exp. Sta. Reps. 15, p. 225, (1902); 16, p. 165, (1903); 17. p. 397, (1904); 18, p. 287, (1905).

CAUSE OF SCAB.

Contrary to the opinion frequently expressed by practical growers, the cause of the potato scab is a specific organism, and is not due as a first cause to any character or condition of the soil. The amount of moisture, nature of the fertilizer used, the alkalinity or acidity of the soil may and do influence to a large degree the *amount* of scab present on a given crop, but if the germs of the disease are not in the soil or introduced into it by means of infected seed tubers or from some other outside source these factors alone are unable to produce the disease. Ashes, lime, stable manure and chip dirt are of themselves incapable of producing scab, but if the land or the seed is already infected their action upon the soil is such that favorable conditions are produced for the development of the scab fungus which manifests itself upon the crop. For this reason a belief that these materials themselves produce the disease is more or less held by practical growers.

The real cause of potato scab was unknown up to 1890 when Dr. Roland Thaxter of the Connecticut experiment station discovered the fungus, to which he afterwards gave the name *Oospora scabies,* and demonstrated the true relationship between the fungus and the disease. Since that date his conclusions have been accepted quite generally by American plant pathologists.

Experiments have shown repeatedly that scab does not develop on new land unless it is infected from some outside agency. If clean seed is used and other precautions are taken a clean crop will result. If scabby seed is used a more or less scabby crop is almost sure to be produced. Because of the readiness with which the disease may thus be spread it follows that most of the infection of new areas comes from scab infested seed. It is probable that scab germs are sometimes introduced into the soil by means of tools or manure and one case is recorded where soil plainly became infected by the water draining off from a potato field on higher ground.*

* Minn. Exp. Sta. Bul. 32, p. 223, (1893).

Once the soil is contaminated there are two possible sources of infection of the growing crop; first from the seed, and secondly from the soil itself. The amount of scab which may develop on the crop is influenced by a variety of conditions, as well as by the number of scab germs already present in the soil or introduced with the seed. For example scabby seed planted on soil where conditions are unfavorable for the development of scab may give a comparatively clean crop, while on the other hand relatively clean seed may produce an exceedingly scabby crop, especially the second year, if the soil conditions are favorable to the scab fungus. This, of course, is due to the fact that the soil is already contaminated. Infested soil may be expected to produce a more or less scabby crop even though clean seed is planted.

CONDITIONS FAVORABLE TO SCAB.

Scab thrives best on an alkaline soil or in the presence of certain fertilizers or chemical substances which tend to promote alkalinity, while acid soils and the presence of certain other chemical salts are unfavorable to its development. Dr. Wheeler of the Rhode Island station has made an extensive study of this subject, and summarizes his conclusions as follows:*

"The materials which favor the scab and which are at times applied to land are: stable manure of all kinds, wood ashes, air-slacked or caustic lime and carbonates of soda (soda-ash), potash, lime and magnesia."

"The materials which do not tend to make the scab worse and which may decrease it are: most commercial fertilizers, seaweed, potash salts (excepting potassium carbonate), land plaster, common salt and ammonium sulphate. Sodium nitrate (Chili salt-peter) if used in large quantities may favor scab eventually, but from the amount usually applied no serious results would be expected to follow. In case a soil were badly contaminated and favorable to the disease, superphosphate, ammonium sulphate, kainite, sulphate and muriate of potash are materials which, applied as fertilizers, would tend gradually to alleviate the conditions."

Heavy moist soils appear to be more favorable to scab than those which are light and dry. It is maintained by some that in

* R. I. Exp. Sta. Bul 40, p. 95, (1896).

like manner a given soil is more likely to produce a badly scabbed crop in a wet season than in a dry season.

The treatment or control of the disease naturally divides itself into two main problems, namely: What measures can be taken to decrease or eradicate the germs from soil already infected and how can the infection of clean soil be prevented?

MANAGEMENT OF INFECTED SOILS.

Various methods of soil disinfection have been attempted, usually by rolling the seed in some chemical disinfectant, mixing the chemical with the soil or scattering it along the row, but this is expensive and has usually resulted in partial or entire failure. At one time it was thought that a practical treatment had been discovered by Halsted of the New Jersey station in using sulphur applied to the soil at the rate of 300 pounds per acre. The results obtained on the station grounds were very satisfactory. Favorable results from the use of sulphur were also obtained by the Delaware station.*

Many others have reported failure with this treatment, so that the general consensus of opinion is that it cannot be relied upon for constant results on all soils. Wheeler suggests that the beneficial results obtained from the use of sulphur is due to its gradual oxidation in the soil and consequent production of acid.† If such is the case it would seem that the sulphur treatment is most likely to prove beneficial on a neutral or slightly alkaline soil. Many Aroostook soils are slightly acid already so that the use of sulphur there might prove positively harmful to succeeding crops like oats.‡

It has been found that most field crops do better on a neutral or slightly alkaline soil and that a large amount of soil acidity may be exceedingly detrimental. In fact the potato itself does better in a slightly alkaline soil, such as is most favorable to the development of the scab. Fortunately it is not so sensitive as the scab fungus, and the amount of acidity developed by green manuring is often sufficient to be very detrimental to the fungus and not materially affect the growth or yield of the potato.

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* Del. Exp. Sta. Bul. 34, p. 19, (1896); Rep. 10, p. 45, (1898).
† R. I. Exp. Sta. Rep. 12, p. 164, (1899).
‡ R. I. Exp. Sta. Rep. 12, p. 165, (1899).

It is not known how long the fungus will remain active in the soil without the presence of a susceptible crop. Various writers have reported a large amount of infection on land where no root crop has been grown for from 5 to 7 years and Jones and Edson* cite a case of probable slight soil infection after a lapse of presumably 25 or more years.

However, by rotation of crops, and proper attention to soil management and fertilization it is possible to materially decrease the amount of scab in an infected soil. Land which has produced a crop of badly scabbed potatoes should at once be given over to other crops as corn, grains, grasses and clovers, for as long a time as possible. Wood ashes or lime should not be applied and such commercial fertilizers as are used should be selected, as far as possible, from the materials mentioned on page 84 as not tending to increase scab. "Souring" the soil by green manuring or plowing under of a green crop such as clover should be resorted to, especially just before a crop of potatoes is again to be grown upon the soil. This has been practiced successfully by Alva Agee of Ohio, using rye as the green crop.† He reports growing 7 successful crops of potatoes on land which in the beginning was so badly infected with scab that the crop was unmarketable. Winter rye was sown in the fall and turned under the first warm days in the spring when about a foot high. Each year the conditions of the crop improved till the third year the appearance of the tubers was excellent and on the seventh year 285 bushels per acre were raised and those nearly free from scab. Aside from the cover crop no fertilizer was used except phosphoric acid in the form of acid phosphate. This system would produce best results on a neutral or slightly alkaline soil and probably would not be entirely successful on a soil which is strongly alkaline, as the decaying crop would very likely not produce acid enough to leave an excess in the soil. Failures in the use of rye in this manner for one season have been reported,‡ but it may be that the soil was too alkaline to produce the required effect.

There it not sufficient experimental evidence to say how nearly an infected soil can be cleared of scab germs or how soon pota-

* Vt. Exp. Sta. Rep. 14, p. 232, (1901).

† Penn Dept of Agr. Bul. 105, p. 84, (1902).

‡ Mass. Exp. Sta. Rep. 8, p. 217, (1890); N. Y. (Geneva) Exp. Sta. Bul. 138, p. 629, (1897).

toes may be included in the rotation without the danger of a large amount of infection. There is reason to believe that possibly the latter can be done in from 3 to 5 years on many soils which are not too strongly alkaline. It is a question which must be settled by the individual grower on his own land. However, if one has a piece of badly infested soil the chances of success are sufficient so that it is well worth while to select fertilizers which do not tend to increase scab, to practice rotation with oats, grass, clover, etc., and to frequently plow under a green crop such as clover, rye or buckwheat.

MANAGEMENT OF CLEAN SOILS.

On clean soils we are not so restricted with regard to the nature of the fertilizers, except that the manure of animals which have been fed on uncooked scabby potatoes or in which the uncooked refuse or skins have been thrown, should not be applied.

There is some difference of opinion on the question of the ability of the scab fungus to pass through the digestive tract of animals without being destroyed. Be this as it may there is practically a certainty that the litter from the mangers and some pieces of unconsumed tubers bearing the spores of the fungus will find their way into the manure, and thus make it a constant source of danger.

For seed *select tubers which are free from scab and disinfect by one of the methods described below.* While very satisfactory results have been obtained in the disinfection of badly scabbed potatoes no method has been devised which will guarantee an absolutely clean crop from scabby seed. Untreated, healthy tubers having been in contact with diseased tubers are almost sure to carry sufficient scab germs to infect the soil.

Bags, baskets, barrels, etc., which have been used for scabby potatoes should not be used for clean or disinfected seed tubers without first being disinfected with formaldehyde gas or solution.

Plows, harrows, planters, cultivators and other implements should be thoroughly cleaned of all particles of dirt, etc., preferably with a stream of water from a garden hose, when changing to clean from infected tubers or land.

DISINFECTING AGENTS.

Corrosive sublimate and formaldehyde (usually sold under the name of formalin) are so far the only agents found to be satisfactory for tuber disinfection. These chemicals as well as the potassium permanganate which is used with formalin to generate formaldehyde gas can be supplied by any druggist.

Corrosive sublimate is a white crystalline powder. It is a deadly poison if taken internally, but is safe to handle provided care is taken to keep the treated tubers and solution away from stock and children. It is a good disinfectant, but on account of its poisonous nature it is doubtful if it would have come into so general use if the value of formaldehyde had been demonstrated earlier. Corrosive sublimate costs about 15 cents per ounce and should be purchased for $1.50 or less per pound.

Formalin is a liquid having a sharp, pungent odor. It is a solution of formaldehyde gas, the best grades containing about 40 per cent. The ordinary commercial goods should show at least 35 per cent, and should not be accepted unless the dealer will guarantee that percentage of formaldehyde, subject to analysis. Compared with corrosive sublimate formalin is equally effective as a disinfectant for scab and possesses the advantage of being absolutely safe to handle. Good formalin should be obtained at from 40 to 50 cents per pint, or even less if bought in any quantity.

Commercial potassium permanganate comes in the form of small, glistening, purple-brown crystals. It is sold for about 30 cents per pound.

METHODS OF DISINFECTION OF SEED POTATOES.

I. *Soaking seed in a disinfecting solution.* Applicable where the acreage is small but impracticable for the large grower or dealer.

(*a*) Formalin solution. Add one-half pint of commercial formalin to 15 gallons of water, stir thoroughly, and soak uncut tubers 2 hours in this solution.

(*b*) Corrosive sublimate solution. In a wooden or earthern vessel (metal vessels cannot be used on account of the corrosive action of the chemical) dissolve 2 ounces of corrosive sublimate in 2 gallons of hot water, and then dilute to 15 gallons with cold water. Place uncut tubers in a sack and soak 1½ hours in this solution.

Either solution can be used repeatedly, fresh being added as fast as it is used up. Mr. Agee recommends, as a time saver, the use of barrels with a spigot at the bottom and placed on boxes. The barrels are filled with potatoes and the solution poured over. When the time of disinfection is passed the solution is drawn off and poured into other barrels, already filled, and the treated potatoes dumped out on the ground to dry. This should be done on a clean grass sod and not on plowed land or in any other place where the treated seed will be exposed to reinfection.

II. *Exposure of dry seed to formaldehyde gas.* Applicable where large quantities, up to car load lots are to be treated at one time.

Place seed tubers in bushel crates or shallow slat-work bins in a tight room. For each 1000 cubic feet of space spread 23 ounces of potassium permanganate evenly over the bottom of a large, flaring pan or pail placed in the middle of the room. Pour over this 3 pints of formalin. Close room at once and do not open for 24 to 48 hours. (See details of method described below.)

During the last decade formalehyde gas has, on account of its merits, become the leading disinfectant for use in rooms following contagious diseases. The most common way of generating the gas has been to place the liquid in a dish over an oil stove or other fire lasting sufficient time to vaporize the entire amount of liquid formalin used, then close the room tightly and leave till the period of disinfection was over. The Vermont experiment station has been trying this method with considerable success in the disinfection of scabby potatoes. The writer has had the immediate oversight of the details of these trials for the past 5 years and is satisfied that the results from this process are fully equal to those obtained by soaking, either in corrosive sublimate or formalin solutions. Certain difficulties were experienced with the process, the chief of which was the element of danger from leaving the fire in the disinfecting room for some hours without attention and the comparatively slow evolution of the formaldehyde gas. In 1905 our attention was called to the potassium permanganate method of generating the

gas as described by Messrs. Evans and Russell of the Maine Laboratory of Hygeine.*

By this method all danger from fire is eliminated as the heat required for the liberation of the gas is generated by the chemical action of the potassium permanganate upon the formaldehyde in the solution. It is true that some of the formaldehyde is used up in the reaction but this is more than offset by the fact that within 5 minutes 80 to 85 per cent of the available gas is liberated, and in this manner the maximum strength of formaldehyde is acting upon the fungus almost at once. Where the gas is liberated by boiling it comes off more slowly, there is constant loss by leakage from the room and at no time is the maximum amount of available gas present in the disinfecting chamber. The results of hundreds of tests with various pathogenic bacteria by Evans and Russell and of one test with potato scab by the writer indicate that gas generated by the permanganate method is equally if not more effective than that generated in other ways.

The disinfection of seed potatoes with formaldehyde gas has not been tried on a commercial basis but the results of repeated trials on a small experimental scale with the gas generated by various means are such that it is believed worthy of recommendation, especially where a convenient and rapid method of treating large quantities of seed at one time is desired.

The room in which the work is to be done should be made as tight as possible and be provided with a tightly fitting door. The conditions which obtain in a good potato house intended for winter storage would doubtless meet the requirements. On account of the large amount of space in the open house it would probably be more economical to partition off an end or a corner for the disinfecting room. This partition need not be of expensive material provided care is taken to make it tight by the use of weather strips and pasting builders' or other heavy paper over the cracks and openings.

While it is known that formaldehyde gas has considerable penetrating power† there is no experimental evidence as to how

* Me. State Bd. Health Rep. 13, p. 234, (1904).

† Me. State Bd. Health Rep. 14, (1906). (Evans' experiments here recorded indicate that the gas can penetrate from one to four thicknesses of silk, cotton flannel and ticking and still be perfectly effective upon pathogenic bacteria.)

deep the tubers may be piled and still have the gas effective on all. Until this is determined it would be best to pile not over one foot deep. Bushel crates made on the open slat-work plan make admirable containers, provided they are stacked up loosely in the disinfecting room after being filled with potatoes. Shallow, slat-work bins could also be built one above the other. If one has only a few bushels of seed to disinfect, a large box tightly covered and provided with slat shelves might serve the purpose. It would be better if the box had a small door at the bottom which can be opened to introduce the disinfecting materials and then quickly and tightly closed.

The process of generating the gas is very simple. For each 1000 cubic feet of space use 23 ounces of potassium permanganate crystals and 3 pints of formalin. Place a large flaring pan or pail in the center of the disinfecting chamber and spread the permanganate evenly over the bottom. Pour the formalin quickly over the permanganate, give the dish one rapid tilt to make sure of thorough mixing, then leave and close the room as quickly as possible. When first mixed no change is apparent but soon a vigorous foaming and boiling is set up, hence it is important that the dish used be of sufficient size to prevent running over. A broad, shallow dish like a dishpan has been found to be more satisfactory than a deep one. "The dishes used need not have sides more than 8 inches in height, *but must have wide bottoms.* A good rule to follow in deciding on the size of the dish to be used is to choose one whose bottom is such that it will just be hidden from sight when the requisite amount of permanganate is poured in and evenly distributed." Tin or galvanized iron dishes are better than earthern jars. The disinfecting chamber should remain closed for 24 to 48 hours. The amount of formalin recommended is three times as much and the time of exposure several times longer than that recommended for killing bacteria, but it will not injure the potato tubers in the least. How much the amount of formalin used and the time of exposure can be cut down and still be sure of destroying the scab germs must be determined by future experimentation.

The seed potatoes can be disinfected some little time before planting provided they are not allowed to come in contact with undisinfected bags, barrels, bins, tools, etc., which have been used for untreated potatoes.

SUMMARY.

The use of untreated seed and the too common practice of reserving unsalable, scabby tubers for planting has resulted recently in a rapid increase of potato scab in Maine. Page 81.

Scab is caused by a minute parasitic fungus. Soil conditions, the application of lime, ashes, chip dirt, etc., may favor the development of scab but are incapable of causing it. Page 83.

Crop infection on old land may come from the soil, from the seed, or from both. On new land the source is largely from undisinfected seed. Page 84.

Alkaline soils, the use of stable manure, lime, ashes, and certain chemicals of an alkaline nature favor the fungus. Acid soils and certain other chemicals are unfavorable to it. Page 84.

Beets and the roots of a few other vegetables are attacked by the disease but the fungus may persist in infected soil for several years without the presence of known host plants. Pages 82 and 86.

Badly infested soils should be devoted to such crops as grains, grasses and clovers, for as long a time as possible. Fertilizers favorable to scab should be avoided and "souring" the soil by green manuring is recommended. Page 86.

On clean soils, only healthy, disinfected seed tubers should be used. Manure containing uncooked scabby potatoes or refuse should be avoided but no other precautions as to fertilizers are necessary. Clean soil may be infected by means of tools, bags, baskets, etc., which have been in contact with infected land or tubers. Page 87.

Small amounts of seed are best disinfected by soaking: (a) 2 hours in solution of one-half pint formalin to 15 gallons water, or (b) one and one-half hours in 2 ounces of corrosive sublimate dissolved in 15 gallons of water. Page 88.

For large quantities of seed, formaldehyde gas, generated by the use of potassium permanganate, is the most practical disinfecting agent. Place seed tubers in bushel crates or shallow, slat-work bins in a tight room. For each 1,000 cubic feet of space spread 23 ounces of potassium permanganate evenly over the bottom of a large pan or pail in center of room. Pour over this 3 pints of formalin, leave room at once and allow to remain tightly closed for 24 to 48 hours. Page 89-91.

Directions for fighting potato enemies will be sent on application. Mail should be addressed to the

Maine Agricultural Experiment Station,

Orono, Maine.